Characterizing Vegetation Fire Dynamics in Brazil through Multisatellite Data: Common Trends and Practical Issues

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ABSTRACT: Correctly characterizing the frequency and distribution of fire occurrence is essential for understanding the environmental impacts of biomass burning. Satellite fire detection is analyzed from two sensors—the Advanced Very High Resolution Radiometer (AVHRR) on *NOAA-12* and the Moderate Resolution Imaging Spectroradiometer (MODIS) on both the *Terra* and *Aqua* platforms, for 2001–03—to characterize fire activity in Brazil, giving special emphasis to the Amazon region. In evaluating the daily fire counts, their dependence on variations in satellite viewing geometry, overpass time, atmospheric conditions, and fire characteristics were considered. Fire counts were assessed for major biomes of Brazil, the nine states of the Legal Amazon, and two important road corridors in the Amazon region. All three datasets provide consistent information on the timing of peak fire activity for a given state. Also, ranking by relative fire counts per unit area highlights the importance of fire in smaller biomes such as Complexo do Pantanal. The local analysis of road corridors shows trends for fire detections with the increasing intensity of land use. Although absolute fire counts differ by as much as 1200%, when summarized over space and time, trends in fire counts among the three datasets

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show clear patterns of fire dynamics. The fire dynamics that are evident in these trend analyses are important foundations for assessing environmental impacts of biomass burning and policy measures to manage fire in Brazil.

KEYWORDS: Vegetation fire; Fire monitoring; Brazilian Amazon

1. Introduction

Biomass burning plays an important role in various aspects of the global climate system, largely because of the effects of trace gas emissions from biomass combustion and the resulting changes to the radiation and energy budget (Crutzen and Andreae 1990; Lenoble 1991; Artaxo et al. 1998; Eck et al. 1998; Ross and Hobbs 1998). Of the total number of fire events observed every year, most occur in the Tropics (Hao and Liu 1994; Dwyer et al. 2000), due to the widespread use of fire for land management, together with the extensive areas of fire-prone native vegetation. Among these areas, the southern and eastern edges of the Brazilian Amazon, known as the arc of deforestation, together with adjacent cerrado (savanna) areas, have the highest consistent fire counts from satellite data of any region in Brazil every year from June to October (Prins et al. 1998; additional information available online at http://www.cptec.inpe.br/queimadas, or http://www.dpi.inpe.br/proarco/bdqueimadas). During these months, a large high pressure system tends to cover the region, inhibiting precipitation and reducing relative humidity due to the subsidence of dry air from the upper levels of the atmosphere (Figueroa and Nobre 1990; Nobre et al. 1998). These circulation patterns result in the retention of smoke emitted by burning over a large horizontal expanse, reducing visibility to the point of closing airports and causing respiratory problems among local populations (Reinhardt et al. 2001).

4. Conclusions

Biomass burning in the Tropics impacts large areas every year, and the Brazilian Amazon is known to be a major contributor to total hot-spot numbers that are detected through satellite imagery. Major drivers of satellite-derived fire numbers (hot spots) are due to physical, socioeconomic, and sensor-inherent factors. Complex interactions among these factors will influence the spatial and temporal characterization of fire activity using different satellite sensors. Here, we assess fire dynamics in Brazil using fire product data from *NOAA-12* AVHRR, and *Terra* and *Aqua* MODIS. Common trends observed across biomes and state boundaries are apparent, but statistically significant differences between sensor-years also exist. This stresses the limitation of making general statements, and the need to consider interannual variability as well as the additional caveats presented in this paper. A more stable result between sensors and years is the timing of fires; the average month of peak fire activity, presented in Table 5, would appear to be a reliable finding. Three road corridors in the Amazon showed a spatial distribution of fire counts that is consistent with distinct levels of land transformation. Still, differences in the numbers depicted by each sensor that was used remained significant.

Limiting vegetation fire analyses to a single sensor's data may lead to the incorrect characterization of a region's fire dynamics, thereby inappropriately affecting public policies of land-use management and fire use. Integrating data from multiple sensors may be the best way to currently assess fire occurrence from satellite imagery down to a reasonable spatial scale (i.e., detection limits as regarding fire size and intensity). Data integration involves consideration of multiple, interdependent elements, such as cloud coverage and biome type, requiring a nontrivial approach to correctly account for these problems. By integrating multiple datasets, we believe it is possible to assess fire continuity over time and space and reduce uncertainties in fire counts derived by a single system. Additional research will be essential to address these challenges of data integration.